National Library of Canada
Bibliothèque nationale du Canada

Canadian Theses Service
Services des thèses canadiennes

Ottawa, Canada
K1A 0N4

CANADIAN THESES

THÈSES CANADIENNES

NOTICE

The quality of this microfiche is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Previously copyrighted materials (journal articles, published tests, etc.) are not filmed.

Reproduction in full or in part of this film is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30. Please read the authorization forms which accompany this thesis.

AVIS

La qualité de cette microfiche dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

Les documents qui font déjà l'objet d'un droit d'auteur (articles de revue, examens publiés, etc.) ne sont pas microfilmés.

La reproduction, même partielle, de ce microfilm est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30. Veuillez prendre connaissance des formules d'autorisation qui accompagnent cette thèse.

THIS DISSERTATION
HAS BEEN MICROFILMED
EXACTLY AS RECEIVED

LA THÈSE A ÉTÉ
MICROFILMÉE TELLE QUE
NOUS L'AVONS REÇUE

Canada

NL 339 (r. 86/01)

National Library of Canada / Bibliothèque nationale du Canada

Ottawa, Canada
K1A 0N4

TC –

ISBN 0-315-23268-4

CANADIAN THESES ON MICROFICHE SERVICE – SERVICE DES THÈSES CANADIENNES SUR MICROFICHE

PERMISION TO MICROFILM – AUTORISATION DE MICROFILMER

• Please print or type – Écrire en lettres moulées ou dactylographier

AUTHOR – AUTEUR

Full Name of Author – Nom complet de l'auteur

Theodore Adrian Van Leeuwen

Date of Birth – Date de naissance
July 26 1956

Canadian Citizen – Citoyen canadien
☑ Yes / Oui ☐ No / Non

Country of Birth – Lieu de naissance
USA

Permanent Address – Résidence fixe
4 Ralston Place
Amherst Nova Scotia
B4H 4A5

THESIS – THÈSE

Title of Thesis – Titre de la thèse

A STUDY OF PUBERTY INDUCTION IN THE GILT

Degree for which thesis was presented
Grade pour lequel cette thèse fut présentée
MSc

Year this degree conferred
Année d'obtention de ce grade
1985

University – Université
University of Alberta

Name of Supervisor – Nom du directeur de thèse
F. X Aherne

AUTHORIZATION – AUTORISATION

Permission is hereby granted to the NATIONAL LIBRARY OF CANADA to **microfilm** this thesis and to **lend** or **sell copies of the film.**

The author reserves other publication rights, and neither the thesis nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

L'autorisation est, par la présente, accordée à la BIBLIOTHÈQUE NATIONALE DU CANADA de **microfilmer** cette thèse et de **prêter** ou de **vendre des exemplaires du film.**

L'auteur se réserve les autres droits de publication; ni la thèse ni de longs extraits de celle-ci ne doivent être imprimés ou autrement reproduits sans l'autorisation écrite de l'auteur.

ATTACH FORM TO THESIS – VEUILLEZ JOINDRE CE FORMULAIRE À LA THÈSE

Signature
Theodore Adrian Van Leeuwen

Date
May 13, 1985

NL-91 (r. 84/03)

Canada

THE UNIVERSITY OF ALBERTA

A STUDY OF PUBERTY INDUCTION IN THE GILT

by

T.A. Van Lunen

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF Master of Science

IN

Animal Nutrition

Department of Animal Science

EDMONTON, ALBERTA
Fall 1985

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR: T.A. Van Lunen

TITLE OF THESIS: A Study of Puberty Induction in the Gilt

DEGREE FOR WHICH THESIS WAS PRESENTED: Master of Science

YEAR THIS DEGREE GRANTED: Fall, 1985

Permission is hereby granted to THE UNIVERSITY OF ALBERTA LIBRARY to reproduce single copies of this thesis and to lend or sell such copies for private, scholarly or scientific research purposes only.

The author reserves other publication rights, and neither the thesis or extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

(signed) T.A. Van Lunen

Permanent Address:

4 Ralston Place

Amherst, Nova Scotia

Ba 1C0

Dated May 13 1985

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "A Study of Puberty Induction of the Gilt" submitted by T.A. Van Lunen in partial fulfillment of the requirements for the degree of Master of Science in Animal Management.

Frank Aherne

Supervisor

Date May 13 1985

Abstract

Two experiments were conducted to study the effects of limit feeding and method of boar exposure on age at puberty of gilts.

In the first experiment a total of 72 gilts were fed either ad libitum or 85% of ad libitum from 27 kg to slaughter. At 140 days of age, the gilts were exposed to one of three mature boars for 30 minutes per day for 10 consecutive days. The gilts were exposed to a different boar each day for three consecutive days. All gilts were checked for signs of estrus daily and were slaughtered 10 days after estrus, at which time the ovaries were examined for verification of ovulation. Gilts not reaching puberty by 270 days of age were slaughtered. Restricting feed intake resulted in significantly lower ($P < 0.05$) growth rate. Age at puberty was significantly ($P < 0.05$) lower for the ad libitum fed gilts while weight at puberty and ovulation rate were unaffected by level of feeding. No differences in dressed weight or fat thickness at slaughter occurred between treatments.

In the second experiment a total of 120 gilts were assigned to various boar exposure treatments. These treatments consisted of: moving a boar to a pen of gilts for 30 minutes per day, moving a pen of gilts to a boar in his pen for 30 minutes per day, moving a boar to a pen of gilts for 24 hours per day, moving a pen of gilts to a pen of 4 boars

for 30 minutes per day, or no boar exposure (control). All gilts were fed ad libitum. At 140 days of age the gilts were mixed and moved to pens of four at which time boar exposure was initiated. All boar exposures were for a 10 day period. Gilts were observed daily for signs of estrus. The gilts were slaughtered 10 days after exhibiting standing heat at which time ovaries were removed and examined to verify ovulation. All gilts not showing signs of heat by 270 days were slaughtered. No significant differences occurred between treatments for rate of gain or feed consumption. Dressed weight at slaughter was also unaffected by treatment. Loin fat thickness was significantly larger ($P < 0.05$) for the gilts to boar treatment compared with the boar to gilts and control gilts. Age, weight and ovulation rate at first estrus were similar for all treatments. The percentage of gilts reaching estrus before 270 days of age was significantly higher for the gilts to boar and 24 hour exposure treatments than for gilts on the control treatment.

ACKNOWLEDGEMENTS

Sincere thanks are extended to Dr. F.X. Aherne, Professor of Swine Nutrition, for his advice, suggestions and encouragement during the course of my studies and experimental work, as well as for his hospitality and friendship during my stay in Alberta. Thanks are also extended to Dr. R.J. Christopherson for comments and advice regarding this thesis.

Thanks are extended to Dr. E.E. Lister, Dr. G.M. Weaver and Mr. F.W. Calder of Agriculture Canada, Research Branch, for the provision of educational leave and research facilities in which to conduct my experimental work.

The assistance of Dr. K.B. McRae of Agriculture Canada, Research Branch, with experimental design and statistical analysis is gratefully acknowledged.

I would like to thank those staff members of the University of Alberta as well as those staff members of the Agriculture Canada Experimental Farm at Nappan who provided advice and assistance during data collection and analysis.

Thanks go to Janice Goodwin for providing text preparation and word processing for this thesis.

To my wife Karen, I extend my deepest appreciation for her encouragement and endurance during odd work schedules and relocations.

Table of Contents

Chapter Page

I. GENERAL INTRODUCTION.....1

II. LITERATURE REVIEW.....3

III. OBJECTIVES.....13

IV. EXPERIMENT 1. FACTORS AFFECTING PUBERTY ONSET IN THE GILT: FEED RESTRICTION.....14

Introduction.....14

Materials and Methods.....15

Results and Discussion.....17

Acknowledgements.....29

V. EXPERIMENT 2. FACTORS AFFECTING PUBERTY ONSET IN THE GILT: METHOD OF BOAR EXPOSURE.....30

Introduction.....30

Materials and Methods.....31

Results and Discussion.....33

Acknowledgements.....45

VI. GENERAL DISCUSSION.....46

VII. REFERENCES.....48

List of Tables

Table		Page
1.	Experiment I: Formulation and Composition of Diet for Growing Gilts	25
2.	Experiment I: Growth Performance to 100 kg	26
3.	Experiment I: Carcass Measurements	27
4.	Experiment I: Reproductive Performance	28
5.	Experiment II: Diet Formulation and Composition	41
6.	Experiment II: Growth Performance to 100 kg	42
7.	Experiment II: Carcass Measurements	43
8.	Experiment II: Reproductive Performance	44

I. General Introduction

One of the advantages of raising pigs compared with other livestock is their prolificacy. According to Hughes and Varley (1980) the average litter size of a sow at parturition is 11.0 pigs. Although average litter size is large for pigs, a great deal of variation exists between ovulation rate and litter size and in litter size between individual sows. Hughes and Varley (1980) indicate that ovulation rate can be as large as 25.0 while litter size ranges from 1 to 16. These figures indicate that there is an urgent need to improve reproductive efficiency in pigs.

Sow productivity can be determined by number of litters per sow per year, litter size and piglet mortality. One factor influencing litter size and number of litters produced per sow per year is the annual replacement rate of sows within the herd. According to Hughes and Varley (1980) the average breeding herd contains 15 to 30 percent gilts at any one time. This being the case, it must be accepted that the replacement gilt will significantly affect overall reproductive efficiency in the herd since gilts produce smaller litters than sows and produce only one litter in their first 12 to 14 months of life.

Because of the economic importance of maximizing reproductive performance of the gilt, it is necessary that research be directed to this area. To maximize reproductive performance, economical and practical methods of reducing the period from birth to first mating must

be developed, while at the same time maintaining an acceptable litter size.

Traditionally gilts have been selected for sow replacement at market weight and an age of approximately 180 days, shortly before their littermates went to slaughter. The gilts have then been held until they reached 240 to 260 days of age and weights in excess of 120 kg before being bred, by which time they reached their third heat. There is some evidence that gilts served at their third estrus will produce larger litters than gilts served at puberty. However, holding gilts for this length of time is expensive and contributes significantly to the producer's costs. This increased cost occurs both as a result of increased feeding, labour and housing costs and as decreased returns at slaughter due to shipping overweight gilts not kept for breeding. If early puberty can be induced in gilts, great economic savings could be achieved by the producer, especially if the gilts reached estrus before optimum market weight. An example of possible feed savings due to early puberty attainment is described by Hughes and Varley (1980). They suggest that if the replacement gilt could produce her first litter of 9 to 10 piglets 30 to 60 days sooner than the current industry norm, a 200 sow unit replacing 30 percent of its sows per year could save up to 9 tonnes of feed annually, as well as increasing the number of pigs produced per sow per year.

The experiments described in this thesis were designed to help reduce age at puberty in gilts and thus reduce breeding herd costs.

II. Literature Review

Puberty, as defined by Dox et al. (1979), is the stage of development at which an individual is first capable of reproduction. In the female pig, puberty is marked by first ovulation and can be affected by many factors including environment (Rampacek et al., 1984), stress (Kirkwood and Hughes, 1982), exogenous hormones (Dziuk and Gehlback, 1966), exposure to a boar (Robison, 1974) and growth rate (Robertson et al., 1951; Warnick et al., 1951; Foote et al., 1956; Haines et al., 1959; Zimmerman et al., 1960; Friend et al., 1981).

Effect of Growth Rate on Age at Puberty

Growth rate in the pig is controlled by many factors, including genetics, environment, management and level of nutrition. Of these factors, genetics and level of nutrition play the largest roles in control of growth rate. Level of nutrition is most easily controlled by the swine manager if manipulation of growth rate is desired. Level of feed intake has been shown to affect age at puberty, however, results have been variable. Anderson and Melampy (1972) reported that out of fourteen experiments, nine indicated delayed puberty by feed restriction, while five experiments resulted in a reduced age at puberty.

To determine what part of the diet influenced puberty attainment in the gilt (i.e. protein, energy), numerous experiments were conducted restricting energy or protein levels in the diets of gilts.

In a trial reported by Friend et al. (1981), groups of 10 prepuberal gilts were assigned to one of three dietary treatments. These treatments consisted of (1) ad libitum high energy diet, (2) low energy diet fed at the same daily dry matter intake as 1, (3) high energy diet fed at the same daily energy levels as in group 2. Limiting dietary energy by either of the above methods had no effect on age or weight at puberty. Sorenson et al. (1961) reported that gilts receiving a low level of energy intake from 22 kg body weight to puberty reached puberty at almost the same age as those receiving a high energy diet (208 vs 210 days). Haines et al. (1959) reported that restricting gilts to 50% of the energy intake of a full fed group resulted in delayed age at puberty (195 to 217 days). O'Bannon et al. (1966) reported that gilts fed a high level of energy from 110 days of age until slaughter were 13 days younger and 21 kg heavier at puberty than those fed a low energy diet during the same time period. Den Hartog and Noordewier (1984) fed energy levels from 1.8 to 3.0 times the metabolizable energy requirement for maintenance to gilts from 12 weeks of age until 3 weeks after insemination. Gilts fed the highest energy level reached puberty 10 days earlier than those fed the lowest level of energy. According to Den Hartog and Noordewier (1984) a modest restriction in energy intake can delay onset of estrus in gilts while a greater restriction of energy

can have even a greater effect. This effect of energy intake might be related to backfat thickness of the gilts. Den Hartog and Noordewier (1984) reported that a high backfat thickness appeared to be favourable for reaching estrus at a young age.

The effects of feeding low protein levels on age at puberty of the gilt have also been studied. Cunningham et al. (1974) reported that gilts fed a 14% crude protein diet from weaning reached puberty 18.7 days earlier than gilts fed 10% crude protein. When adjustments were made for differences in growth rate, no differences existed between the two treatments for age at puberty. Wahlstrom and Libal (1977) reported that gilts fed 14% crude protein during growth gained faster and were heavier and younger at puberty than gilts fed 10% crude protein. These data suggest that nutrition may be an important determining factor in puberty attainment in the gilt.

Despite the controversy which exists regarding the effects of level of nutrition on age at puberty in gilts, limit feeding may not be a viable option for replacement gilts. Limit feeding can reduce body reserves of such essential elements as calcium, phosphorus and fat. Reduced calcium and phosphorus stores may lead to increased feet and leg problems while decreased body fat could lead to serious reproductive problems. Work by Frisch (1974) indicates that the ratio of lean body weight to fat is important in determining sexual maturation in humans as well as in maintaining cyclical activity after puberty. Therefore, it

may be important that the gilt contain a certain minimum level of body fat at time of service. Data from Record of Performance home test results from 1971 to 1984 clearly show that gilts have been progressively selected for leanness. At mating, gilts may now contain only 13 percent body fat, whereas 10 years ago they contained 21 to 25 percent body fat (Aherne, 1982).

The effects of level of feeding of pregnant and lactating sows on body fat reserves is discussed by O'Grady et al. (1975). It was reported that gilts fed very high energy levels lost a considerable amount of body fat by the end of their third parity. Whittemore et al. (1980) suggests that gilts or sows may actually show a positive body weight gain while still losing considerable amounts of body fat reserves. These data suggest that gilts destined for use in the breeding herd be ad libitum fed an adequate diet in order to attempt to avoid any future reproductive problems.

There are many reports in the literature regarding the effects of genetics on age at puberty in the gilt. Christenson and Ford (1979) reported that, of five different breeds, Landrace gilts were youngest at puberty (173 days) and Duroc gilts oldest (224 days), while Hampshire, Large White and Yorkshire were intermediate with 207, 211, and 221 days of age at puberty, respectively. Comparisons of breeds can vary according to the individual pigs involved, but this does give an indication of differences which can exist between different genetic groups.

Crossbreeding inbred lines of pigs generally reduces age at puberty. Zimmerman et al. (1960) crossed Poland China and Chester White gilts which resulted in gilts which attained puberty earlier than either of the parent breeds. Hutchens et al. (1981) estimated heritability of age at puberty to be 0.19. This indicates that selection for a younger age at puberty may result in slow but gradual genetic improvement. However, Hutchens et al. (1981) also observed a negative correlation between age at puberty and growth rate. This suggests that continual selection for growth rate could result in a correlated increase in age at puberty.

The work of Warnick et al. (1951), Reutzel and Sumption (1968) and Aherne and Price (1979) indicate that faster growing gilts are older at puberty. However, environmental effects, such as nutrition, which may increase rate of gain, can lead to a younger age at puberty. This apparent paradox is explained in terms of a genetic factor "...the mechanism involved is presumably that any genetic factor which delays puberty would also delay the onset of the catabolic effects from the surge of estrogens around that time. This would allow maximum growth rate to persist, and hence inflate the apparent growth rate of non-puberal gilts to any time - or weight - constant end point" (Aherne and Price, 1979).

Effect of Boar Exposure on Age at Puberty

Boar exposure has been shown repeatedly to be a reliable and effective stimulus for decreasing the age at which gilts reach puberty (Robison, 1974; Hughes and Cole, 1975; Kirkwood and Hughes, 1979; Perry, 1980).

Various aspects of boar exposure are reported in the recent literature. According to Kirkwood and Hughes (1980b) age of the boar is important for stimulating the onset of puberty in gilts. It is suggested that for successful puberty induction, a boar older than 10 months of age must be used.

Brooks and Cole (1970) reported that continuous boar exposure was successful in puberty induction of gilts while Kirkwood and Hughes (1980a) reported similar success with 30 minute daily exposure.

Deligeorgis et al. (1984) reported that boar exposure must include physical contact as well as visual, auditory and olfactory stimulation. In a test using 63 gilts, no difference in age at puberty was observed between gilts exposed to a boar through a mesh partition and gilts not exposed to a boar. Gilts which had contact with a boar within a pen reached puberty 24.3 days earlier than the gilts exposed to a boar through a mesh partition.

Hughes and Cole (1975) reported that the ability to induce early puberty in gilts varied between individual boars. A similar difference between individual boars was also reported by Kirkwood and Hughes (1980b). They suggested that the androgen steroid present in the saliva from the submaxillary salivary gland of the boar was the stimulant which facilitated the sexual response in the gilt. Perry (1980) determined that the presence of submaxillary salivary glands in the boar was essential to elicit standing heat in gilts. Booth (1972) identified high concentrations of 16-unsaturated C_{19} steroids in the submaxillary gland of mature boars. When the boars were castrated these steroids disappeared. Melrose et al. (1971) suggested that since these steroids are closely related to the male sex hormones and their production is inhibited by castration, it is possible that they might influence the behavior of the female during or prior to estrus. Although similar pheromones are found in boar urine as well as the submaxillary salivary gland, Kirkwood and Hughes (1980b) have suggested that only the salivary pheromones can elicit early puberty in gilts. Recent work by Booth (1984) has suggested that salivary pheromones may not be as important to puberty induction of the gilt as was originally thought. A greater proportion of gilts (100% vs 33%) reached puberty by 247 days of age when physically exposed to a boar as compared to exposure to a nasal spray of boar saliva containing 16-androstene steroid hormones. From this study and work by Kirkwood et al. (1983) it appears that pheromones alone play a minor role in puberty induction of the gilt. Booth (1984) suggests that the olfactory component in boar exposure involves a

complex of pheromones originating from a number of sources in the boar. These pheromones may have to act in conjunction with other sensory inputs such as auditory, visual and tactile stimuli in order to produce a stimulating effect. Despite the fact that pheromones may not play as large a role in puberty induction as originally thought, it appears their presence may still be essential. The effect of pheromones on puberty induction may explain why boars must be over 10 months of age and why they vary individually in their ability to induce puberty in gilts. It may be that pheromone production in the boar reaches a critical level at approximately 10 months of age and is variable in amount produced between individual boars.

Gilts can be raised with castrates, gilts or boars up to 165 days of age without any significant effect on their subsequent response to boar exposure by an unfamiliar boar according to work done by Paterson and Lindsay (1980). Work by Eastham et al. (1984) shows similar results. Barber et al. (1980) have shown that mixed sex groups perform just as well as single sex groups of pigs in terms of rate of gain and feed efficiency.

Age of the gilt at first boar contact has been studied by several researchers (Brooks and Cole, 1970; Zimmerman et al., 1974; Aherne et al., 1976; Hughes and Cole, 1976; Kirkwood and Hughes, 1979) with no clear concensus as to the optimum age at exposure. Brooks and Cole (1969) suggest that exposing (Landrace x Large White) crossbred gilts to

a boar at too early an age can delay rather than accelerate the onset of puberty, while Hughes and Cole (1976), working with similar crossbred gilts, suggests no advantage to waiting past 160 days of age. Kirkwood and Hughes (1979) suggest that the optimal gilt age at which to begin boar exposure in order to induce puberty in (Landrace x Large White) crossbred gilts is in the range of 160 to 170 days. Brooks and Cole (1969) report that greatest synchronization in estrus may occur when gilts are between 165 and 180 days of age at first boar exposure. Aherne et al. (1976) suggests that boar exposure at an age younger than 110 days may induce gilts into early puberty. Lacombe gilts were exposed to a mature boar at 55 kg live weight and attained puberty at an average age of 145 days (range 102 - 200 days). Zimmerman (1976) reported similar results with gilts of unspecified breeding.

Reaction to boar exposure can vary between individual gilts of the same age. Paterson (1982) suggested that the response to boar exposure depends on the general maturational status of the gilt. This maturational status is manifested in the gilts' ability to initiate follicle growth and to respond to resulting elevated estradiol levels. This difference between individuals may help explain the variable results reported in the literature regarding optimum age at boar exposure.

Little information is available in the literature regarding the physiological mechanisms of puberty induction by boar exposure. Bronson

and Desjardins (1974) studied male stimulated puberty in the female mouse and reported that the introduction of the male causes a peak in serum luteinizing hormone (LH) (1 h later) followed by two peaks in plasma estradiol levels (4 and 24 h later). Deligeorgis et al. (1984) suggests that a period of elevated estrogens may be essential for the final maturation of the positive feed-back system in the hypothalamus, which then facilitates the release of gonadatropins in response to stimulation by estrogen. Luteinizing hormone, follicle stimulating hormone (FSH) and progesterone concentrations increase similarly to the pre-estrus phase of the adult cyclic mouse resulting in ovulation. Paterson (1982) demonstrated similar plasma estradiol patterns in the gilt to those reported to occur in the mouse during the estrus cycle.

III. Objectives

The objectives of this study were to evaluate the effects of nutritionally controlled growth rate and method of boar exposure on age and weight of gilts at puberty.

IV. Experiment 1. Factors affecting puberty onset in the gilt: feed restriction.

Introduction

Numerous studies of the effect of level of feed intake on age at puberty in the gilt have been reported in the literature. A review by Anderson and Melampy (1972) reported that out of 14 experiments, 9 indicated delayed puberty by restricting feed, while 5 resulted in decreased age at puberty when feed was restricted. Pay and Davies (1973) reported that no significant difference existed for age at puberty between gilts fed 1.4 or 2.3 kg of feed per day during their growing phase, although weight at puberty was significantly different between the two treatment groups (77 kg vs 115 kg).

A number of reports have indicated that reduced growth rate due to restricted feeding can delay onset of puberty in the gilt (Robertson et al., 1951; Warnick et al., 1951; Foote et al., 1956; Haines et al., 1959; Zimmerman et al., 1960). Friend et al. (1981) reported that limit feeding of gilts resulted in an 11 day increase in age and 5 kg decrease in weight at puberty when compared to gilts fed ad libitum. Some reports indicate no effect on age at puberty when gilts were limited in energy intake (Sorenson et al., 1962; Friend et al., 1981), while others

have reported that restricting energy intake delayed age at puberty of gilts (Haines et al, 1959; O'Bannon et al., 1966). Friend (1977) reported that protein level of the diet had no effect on age at puberty of gilts, while Cunningham et al. (1974) and Wahlstrom and Libal (1977) reported that gilts fed 14% crude protein diets were younger at puberty than gilts fed 10% crude protein diets.

In view of the controversy which exists regarding the effects of level of nutrition on age at puberty, this experiment was conducted to evaluate the effects of feed restriction on growth rate and age at puberty of gilts.

Materials and Methods

Seventy-two (Landrace-Yorkshire) crossbred gilts in groups of 2 littermates were each assigned to one of two levels of feeding (ad libitum vs limit). The use of limit feeding in this experiment was not intended to develop a feeding system for pre-pubertal gilts, but rather to study the effects of nutritionally controlled growth rate on puberty attainment and ovulation rate in the gilt. Gilts averaged 27 $\pm$ 5 kg body weight and 73 $\pm$ 6 days of age at the start of the experiment. They were allotted according to weight to pens of two in a randomized block design with one littermate on each of two levels of feed intake.

Animals were housed in a conventional, heated swine unit in one of four wings completely separated from other pigs, including boars. Pens were 1.22 x 3.05 m in size with solid concrete floors bedded with sawdust. Each pen contained one automatic nipple drinker providing water ad libitum. Single metal feeders were provided in the ad libitum pens while limit fed pigs were floor fed twice daily. Limit fed gilts were fed 85% of the amount of feed which gilts of the same weight on the ad libitum treatment had consumed. Feed allocations were calculated on a weekly basis. The temperature of the barn was maintained at 19°C and artificial light was provided for 18 hours per day at a minimum intensity of 19 lux at pig level. The experiment was initiated in late December and ended in June. All gilts were fed a commercial hog grower diet containing 15.9% crude protein (Table 1) for the entire test period. All animals were weighed and their feed consumption monitored on a weekly basis by weighbacks and visual estimates of wastage.

At 140 days of age, all gilts were exposed to 1 of 3 mature (13 months of age) boars in a daily rotation for 30 minutes per day for ten days. This was done by moving each pen of 2 gilts to the boar. During boar exposure, each gilt was closely observed for signs of estrus and receptivity to the boar. From age 150 days until slaughter, each gilt was checked visually at 8:00 a.m. on a daily basis for reddening and swelling of the vulva and the standing reaction to back pressure. The first exhibition of standing heat for each gilt was recorded and verification of first ovulation was made by examination of the ovaries

at slaughter 10 days later. Ovary examination included the determination of the presence and number of corpora lutea and corpora albicantia. Any gilt not showing signs of estrus by 270 days of age was slaughtered and examined according to the above procedure.

Analysis of variance was performed on the data in order to determine significant differences between treatments. Differences between groups of means were determined by the Student-Newman-Keuls multiple range test. Comparison of percent of gilts in heat by 270 days of age was made using a chi-squared analysis (Steel and Torrie, 1980).

Results and Discussion:

The effects of limit feeding on growth performance to 100 kg are shown in Table 2. Since the gilts were slaughtered at various weights over 100 kg during this test, a standard weight of 100 kg was used to allow direct treatment comparisons of growth performance data. Starting weights for the gilts on each treatment were similar. The ad libitum gilts had a significantly higher average daily gain (ADG) ($P < 0.05$) than the limit gilts. The effect of limit feeding on ADG was as expected; the limit fed gilts did not receive a level of feed capable of supporting a high growth rate. There was no significant difference between treatments for total gain.

Differences in total feed consumption to 100 kg data between treatment groups were not significant. It should be noted that feed consumption records were based on pen rather than individual feed intake and this makes it more difficult to find significant differences between treatments. Numerical differences in total feed consumption existed between the ad libitum and limit gilts with the ad libitum gilts consuming less feed. Similar results are apparent for feed/gain ratios with ad libitum gilts having numerically lower ratios than limit gilts. The differences between limit and ad libitum fed gilts in total feed consumption might be explained by the greater number of days required to reach 100 kg and thus a greater total maintenance requirement to that weight. This might also explain the poorer feed/gain ratios for the limit fed gilts. Daily feed consumption was significantly higher ($P < 0.05$) for ad libitum gilts compared with limit fed gilts.

The effects of limit feeding on carcass quality at slaughter are shown in Table 3. There were no significant differences between treatments for any of the carcass quality traits measured.

The effect of limit feeding on puberty attainment and ovulation rate is shown in Table IV. A significant difference ($P < 0.05$) in 140 day weight existed between ad libitum and limit gilts. This result is related to the growth performance data previously discussed and reflects differences in levels of feed consumption.

Analysis of the data was complicated by the fact that different numbers of gilts in each treatment group attained puberty by 270 days of age. The ad libitum treatment had 72.2% of gilts in heat by 270 days while the limit treatment had 58.3% of gilts in heat by 270 days of age. These percentages are low compared to results reported in the literature. Aherne et al. (1976) reported that all gilts exposed to a boar were in heat by 200 days of age. Brooks and Cole (1970) exposed gilts to a boar at 165 or 190 days of age or isolated gilts from boars. Out of 48 pigs, only two had not reached puberty by 250 days.

There are a number of factors which may have contributed to the large number of gilts not reaching puberty by 270 days of age. The genetic background of the pigs may have had an effect on age at puberty. Warnick et al. (1951) reported that major differences in age at puberty exist between inbred lines of pigs. The herd from which this group of gilts originated was known to have late maturing gilts. Rate of gain may also have had an effect. The growth rate data indicates that the gilts had the potential for fast growth as indicated from the daily gain of the ad libitum fed gilts. Reutzel and Sumption (1968) suggest that the genetic ability for fast growth also acts to increase age at puberty. Kirkwood and Aherne (1984) suggest that selection for leanness may result in selection for later maturity. The gilts on this test were not measured for backfat thickness at 100 kg (market weight) but the estimated herd average for loin fat thickness of the herd of origin was 2.92 cm at 100 kg live weight. This relatively low level

suggests that leanness may have played a role in the late pubertal ages of the gilts on test.

Although the difference of percent in heat by 270 days between treatments creates some problems in data analysis, it is an indication of the effects of limit feeding on age at puberty of gilts. This difference was not significant but still represents a numerical difference of 13.88%.

The age and weight at puberty of those gilts attaining sexual maturity by 270 days of age is shown in Table 4. A significant difference ($P < 0.05$) of 26 days existed between the treatments for mean age at puberty while no difference existed for weight at puberty.

Mean ovulation rate, as expressed by the number of corpora lutea present on the ovaries, was calculated from the gilts which had reached puberty by 270 days of age. No significant differences in ovulation rate appeared between treatments. No evidence of silent heats was found in ovaries of those gilts not reaching puberty by 270 days of age.

Despite the fact that not all gilts attained puberty by 270 days of age, some definite trends are apparent. It appears that level of feeding does influence the attainment of puberty in gilts. The ad libitum fed gilts had the fastest rate of gain and reached puberty 26 days sooner than the limit fed gilts. By 270 days of age, 72.22% of ad

libitum fed gilts had reached puberty while only 58.34% of the limit fed gilts had attained puberty.

There are numerous reports in the literature regarding the effects of level of nutrition on puberty attainment and ovulation rate in the gilt. Anderson and Melampy (1972) reviewed 14 experiments in which gilts were restricted in feed intake. Of those 14 experiments, 9 indicated delayed age at puberty and 5 reduced age at puberty of gilts by limit feeding. Deligeorgis et al. (1982) fed gilts at intakes of 60, 80 and 100% of ad libitum and observed no treatment effects on reproductive development as measured by number of gilts in heat, ovary weight, uterine weight and number and weight of follicles. Friend (1976) and Friend et al. (1981) reported a later age at puberty for limit fed gilts. The effects of limiting energy and protein levels in diets on age at puberty in gilts have also been reported. Friend (1977) and Friend et al. (1981) reported no effect on age at puberty of gilts fed high and low energy diets ad libitum. Sorenson et al. (1961) reported similar results to Friend (1977) and Friend et al. (1981) while O'Bannon et al. (1966) reported opposite results. Cunningham et al. (1974) reported that gilts fed a 14% crude protein diet were heavier and younger at puberty than those fed a 10% crude protein diet. Wahlstrom and Libal (1977) reported that gilts fed a 14% crude protein diet were 25.5 days younger at breeding on their third heat as compared to gilts fed 10% crude protein. It was also reported that number of corpora lutea was unaffected by treatment. Friend (1973) suggested a possible

delay in puberty attainment by feeding diets with amino acid imbalances.

From the literature cited above, it appears that nutritionally controlled growth rate can play a role in age at puberty of gilts. The results from this experiment tend to confirm that conclusion. Although there were differences in mean age at puberty between the treatments in this trial, there were no differences in mean weight at puberty. The gilts in this experiment had similar genetic backgrounds since they all originated from the same herd and common sires were used on the dams. Warnick et al. (1951) reported differences in age at puberty due to genetics between genetic lines but not within lines. It appears that for the gilts in this experiment, a key weight had to be reached before sexual maturation could take place. This theory may be supported by Dickerson et al. (1964) where gilts were severely restricted in feed intake for a long period of time after which they were rehabilitated. No ovulation occurred until the gilts reached a weight similar to the weight of gilts which reached puberty under normal conditions. This key weight may not be identical for all gilts in a group, but might fall within an age-weight relationship, which could vary from one group or line of gilts to another.

Work with humans shows similar trends to this study. Frisch and Revelle (1970, 1971) noted that inadequate nutrition delayed the onset of menarche in girls, however, all girls reached menarche at similar body weights. Frisch et al. (1973) suggests that body composition,

especially body fatness, may be an important parameter in puberty attainment in the human female. Monteiro and Falconer (1966) reported that female mice reached sexual maturity at approximately the same weight, but at widely different ages.

According to Kirkwood and Aherne (1984) no single factor controls puberty onset. A minimum age and fatness may have to be achieved prior to the onset of puberty, however, other factors such as boar exposure can have an inhibitory or stimulatory effect as well. Den Hartog and Noordewier (1984) suggest that previous studies indicated both a minimum and maximum fat content of the body was required for puberty attainment.

The backfat thickness at slaughter of the gilts on this test was normal for pigs of that weight and no significant difference existed between treatments for backfat. From this, one can assume that the minimum fat level was surpassed for these pigs, and therefore, had little effect on treatment results.

From the literature, it appears that no clear cut, simple relationship of one physiological parameter (i.e. fat level) controls the onset of puberty in gilts. According to Kirkwood and Aherne (1984) certain prerequisites exist for puberty attainment. These are: minimum age,

weight and level of fatness. A gilt must attain a minimum age before she is physiologically prepared for puberty attainment. This age can vary to a degree between individuals. She must also have attained a minimum body weight in order to be receptive to puberty-inducing stimulation. Kirkwood and Aherne (1984) suggest that this critical weight is not identical for all individuals, but rather may be age dependent. Fat level, in association with age and weight, may be the final physiological factor required for puberty attainment. If age and weight criteria are met and the minimum body fat level is achieved, the gilt is physiologically ready to respond to puberty stimulation. Age at a particular weight and/or degree of fatness is influenced by growth rate. If growth rate is reduced by level of feeding, weight and fat level per unit of age will be decreased. This decrease, according to the literature and the results of this test, can delay the onset of puberty in gilts limit fed if all other factors are equal.

TABLE 1: EXPERIMENT I: FORMULATION AND COMPOSITION OF DIET FOR GROWING GILTS

Ingredients	Percent of Diet
Barley	74.8
Wheat	10.0
Canola Meal (36% CP)	5.0
Meat Meal (50% CP)	4.5
Fish Meal (63% CP)	0.5
Soybean Meal (49% CP)	1.1
Iodized Salt	0.4
Ground Limestone	0.7
Lignosol (Pellet binder)	2.5
Vitamin - mineral premix[1]	0.5

Composition (Analyzed):

Crude Protein (%)	15.9
Cellulose (%)	9.2
Calcium (%)	0.99
Phosphorous (%)	0.68
DE (MJ/kg - calculated)	12.62

[1]Supplied the following per kg of diet: 8,800 IU Vitamin A; 900 IU Vitamin D_2; 25 IU Vitamin E; 3.5 mg Riboflavin; 14 mg Pantothenic acid; 21.0 mg Niacin; 30 ug Vitamin B_{12}; 0.5 mg Folic acid; 3.5 mg Manganese; 120 mg Zinc; 3 mg Copper; .1 mg Selenium; 21 mg Iron.

TABLE 2: EXPERIMENT I; GROWTH PERFORMANCE TO 100 Kg

	Starting Weight[1] (kg)	Average Daily Gain (kg)	Total Gain (kg)	Total Feed (kg)	Feed/Day (kg)	Feed/Gain
Ad libitum	27.22	0.78[a]	71.68	237.91	2.56[a]	3.32
Limited intake	26.69	0.66[b]	73.16	263.95	2.34[b]	3.57
Significance	NS	($P < 0.05$)	NS	NS	($P < 0.05$)	NS
Standard Error	0.84	0.01	0.89	5.76	0.08	0.16

[1]Means within columns with the same subscript are not significantly different ($P > 0.05$)

TABLE 3: EXPERIMENT I: CARCASS MEASUREMENTS

	Slaughter Weight[1] (kg)	Dressed Weight (kg)	Dressing %	Backfat (cm)
Ad libitum	141.34	117.92	83.43	3.74
Limited intake	135.30	109.88	81.20	3.58
Significance	NS	NS	NS	NS
Standard Error	2.11	1.86	0.37	0.01

[1]Means within columns with the same subscript are not significantly different ($P > 0.05$)

TABLE 4: EXPERIMENT I: REPRODUCTIVE PERFORMANCE

	140 Day Weight[1] (kg)	Percent in Heat by 270 Days	Age at Puberty[2] (Days)	Weight at Puberty[2] (kg)	Ovulation Rate[3] (CL)
Ad libitum	75.10[a]	72.22	212.60a	135.18	12.3
Limited intake	66.90[b]	58.34	238.60b	133.13	12.0
Significance	$P < 0.05$	NS	$P < 0.05$	NS	NS
Standard Error	1.47	--	4.29	2.83	0.33

1 Means within columns with the same subscript are not significantly different ($P < 0.05$).

2 Of those gilts attaining puberty by 270 days of age.

3 Ovulation rate is estimated from the number of corpora lutea present on the ovaries of those gilts which attained puberty by 270 days of age.

Acknowledgements:

The assistance of K.B. MacRae, A.E. Foster and S.B. Bird is gratefully acknowledged.

V. Experiment 2. Factors affecting puberty onset in the gilt: method of boar exposure.

Introduction

Work by Brooks and Cole (1970) has shown that exposure to a mature boar can facilitate the onset of puberty in gilts. These findings have been substantiated in numerous reports (Robison, 1974; Hughes and Cole, 1975; Hughes and Cole, 1976; Thompson and Savage, 1978; Kirkwood and Hughes, 1979; Perry, 1980) and boar exposure is gaining acceptance as a simple tool for decreasing age at first heat in gilts.

Despite the fact that boar exposure is accepted as a method of inducing early puberty in gilts, a great deal of variation exists in the literature regarding the effectiveness of boar induced puberty of gilts. Aherne et al. (1976) reported that gilts exposed to a boar attained puberty at a mean age of 145 days, while Hughes and Cole (1976) reported that gilts exposed to a boar reached puberty at 169.4, 178.2 and 205.3 days of age, depending on initial age at boar exposure. The latter authors suggested that boar exposure earlier than 160 days may delay rather than reduce age at puberty, but this is clearly not consistent with the results of Aherne et al. (1976).

The variation in results reported in the literature in regard to the degree of effectiveness of boar exposure requires further study.

Although boar exposure has been widely studied, the methods of boar exposure used vary between experiments, thus possibly affecting results.

Many questions remain unanswered regarding boar exposure; for example: Is 10 minute exposure as effective as 30 minutes? Is 15 minutes of exposure twice per day as effective as 30 minutes once per day? The work of Kirkwood and Hughes (1980a) comparing continuous to 30 minute boar exposure requires further study since low numbers (10 gilts per treatment) were used. In practical terms, it may be more acceptable for the breeding herd manager to use continuous boar exposure with his gilts. If this is true, it should be determined if continuous exposure is as effective as daily exposure. Other questions which arise regarding boar exposure are basic ones such as the differences between moving gilts to boars or boars to gilts, individual gilt exposure versus a group of boars exposed to a group of gilts. This experiment was designed to evaluate various methods of boar exposure in order to identify which methods are most successful.

Materials and Methods

Forty purebred Yorkshire gilts were obtained from the Nova Scotia Agricultural College at 10 to 12 weeks of age and housed in groups of six and were fed and managed similarly until they reached 140 days of age. At 140 days of age and 70.58 kg, the gilts were mixed and moved to

a separate wing of the barn where they were randomly assigned in groups of four to one of five treatments. The experiment was replicated three times resulting in a total of 120 gilts on test. The five treatments were: a pen of gilts moved to the boar's pen for 30 minutes daily exposure; a boar moved to a pen of gilts for 30 minutes daily exposure; a boar continuously kept in a pen of gilts for 24 hours daily exposure; a pen of gilts moved to a pen of four boars for 30 minutes daily exposure; a control group with no boar exposure. All boar exposures began at a gilt age of 140 days and continued for 10 days thereafter. Gilts on 30 minutes daily exposure to a single boar were exposed at 8:30 a.m. to one of three mature (20 month old) boars on a daily rotation. The gilts exposed to a group of boars were moved daily to one of two groups of four boars at 8:30 a.m. on a rotational basis. Control gilts were housed in pens adjacent to gilts to boar and/or gilts to 4 boars pens so that possible contact with a boar would be minimized. During boar exposure, all gilts were observed for signs of estrus and receptivity to the boar. After the initial 10 day period, all gilts were observed daily at 8:30 a.m. for signs of estrus until each gilt reached puberty. Estrus was determined by observation of reddening and swelling of the vulva and the exhibition of a standing response when back pressure was applied. When the first exhibition of standing heat was recorded, its coincidence with first ovulation was verified 10 days later at slaughter. All gilts were slaughtered at a local slaughter facility at which time their ovaries were recovered and examined for the presence and number of corpora lutea and corpora albicantia.

The gilts were housed in concrete floored pens (2.44 x 3.05 m) with solid partitions and sawdust bedding. A pelleted grower (Table 5) was fed ad libitum throughout the experiment. Pen feed intake and individual live weight gains were recorded weekly. Water was available ad libitum via automatic nipple drinkers while the temperature in the barn was maintained at 18°C. Light was provided for 18 hours per day via incandescent bulbs at a minimum intensity of 19 lux at pig level as measured by a light meter.

Analysis of variance was performed on the data in order to determine significant differences between treatments. Differences between groups of means were determined by the Student-Newman-Keuls Multiple Range Test. Percentage comparisons between treatments for number of gilts in heat by 270 days were made using a chi-square analysis (Steel and Torrie, 1980).

Results and Discussion

During the experiments, eight gilts died or were removed from test. All deaths and removals were unrelated to treatments (i.e. pneumonia, lameness, prolapsed rectum). Two gilts were lost from the gilts to boar treatment, one from the boar to gilts treatment, one from 24 hour exposure, one from gilts to group of boars and three from the control group.

Growth performance to 100 kg of the gilts on each treatment is shown in Table 6. Since the gilts were slaughtered at various weights over 100 kg, a standard weight of 100 kg was selected to allow for direct treatment comparisons. As can be seen in the table, all growth performance parameters were similar across treatments. The mean starting weight on test was 70.58 kg and it took an average of 37.13 days to reach 100 kg from that starting weight. Mean average daily gain from 70 to 100 kg was 0.84 kg per day resulting in a mean total gain of 29.48 kg. Mean total feed consumption for this growth period was 102.87 kg resulting in a mean daily feed consumption of 3.25 kg per day and a mean feed conversion (Feed/Gain) value of 3.47.

The lack of significant differences between treatments for the growth performance data is not surprising since all gilts were housed and fed alike. The growth rate parameters and feed efficiency values indicate that the gilts were fast growing and utilized feed efficiently.

The carcass data of the gilts slaughtered 10 days post estrus or at 270 days are shown in Table 7. As can be seen, there was no difference in live weight at slaughter or dressed weight between gilts on any of the treatments. There was, however, a significantly higher ($P < 0.05$) mean fat thickness for the gilts to boar treatment versus the boar to gilts and control gilts. This is in spite of lower slaughter weight. This result is difficult to explain since all gilts were housed and fed alike and were derived from the same herd.

The effects of method of boar exposure on reproductive performance are shown in Table 8. Differences occurred in the percent of gilts on each treatment that reached puberty by 270 days of age. Although differences were not statistically significant, it was apparent that a higher percentage of gilts reached puberty by 270 days of age on the gilts to boar and 24 hour exposure treatments. The lowest percentage in heat by 270 days occurred for the control (no boar exposure) treatment. Of those gilts that did attain puberty by 270 days of age, no differences in age at puberty, weight at puberty or ovulation rate existed between treatments.

Mean age and weight at puberty across treatments was 208.1 days and 129.0 kg respectively for those gilts attaining puberty by 270 days of age. Mean ovulation rate at first heat was 12.7. The mean age at puberty of those gilts reaching puberty by 270 days of age was slightly high compared to values of approximately 200 days appearing in the literature (Duncan & Lodge, 1960; Dyck, 1971; Anderson and Melampy, 1972). The age of 208.1 days and weight of 129.0 kg at puberty for the gilts on this test is similar to values estimated for their herd of origin where boar exposure is used for puberty stimulation. From the above, this later age at puberty of the gilts on test appears to be due to genetics. Warnick et al. (1951) reported that major differences in age at puberty exist between inbred lines of pigs.

The lack of difference between treatments for ovulation rate might be related to body weight. Perry (1982) reported that ovulation rate

might be dependent on body weight. Ovulation rate tends to increase with increasing body weight at puberty as reported by Paterson and Lindsay (1980). Since weight at puberty of those gilts in heat by 270 days of age was similar for all treatments in this experiment, it would be expected that ovulation rate would be similar across treatments as well.

Although mean age at puberty for the gilts was high, it is apparent that treatment differences did exist. The gilts on the control treatment (no boar exposure) had a numerically lower percentage of gilts in heat by 270 days of age as compared to the boar exposure treatments, and significantly lower ($P < 0.05$) than the gilts to boar and 24 hour exposure treatments. From this it may be assumed that boar exposure did have an effect on puberty attainment in the gilts. This result is well established in the literature. It has been demonstrated many times that exposure of prepubertal gilts to a mature boar can advance the onset of first heat (Brooks and Cole, 1969; Robison, 1974; Mavrogenis and Robison, 1976; Hughes and Cole, 1976; Thompson and Savage, 1978; Kirkwood and Hughes, 1979).

Despite the fact that mean ages and weights at puberty were similar across treatments, the percentage of gilts in heat by 270 days of age varied between boar exposure treatments. From these percentage results it appears that method of boar exposure may affect the onset of puberty in the gilt. By moving the gilts to the boar for 30 minutes per day for

10 days or by continuous boar exposure for 10 days, numerically more gilts were in heat by 270 days as compared to moving the boar to the gilts or exposing a group of gilts to a group of boars for 30 minutes per day for 10 days (68.2 and 65.2 vs 47.6 and 47.6 respectively). Significance ($P < 0.05$) only occurred between the gilts to boar and 24 hour exposure gilts versus the control gilts.

Scheimann et al. (1976) compared moving the boar to the gilts versus the gilts to the boar at a gilt weight of 81.5 to 90.5 kg. Seventy-eight percent of the gilts taken to the boar reached puberty within 17 days of the start of boar exposure as compared to 56.5 percent of those gilts with the boar taken to them. This result is similar to that obtained in this study. An explanation for this may lie in the stress of moving the gilts from their own pen to the unfamiliar boar pen located in a separate wing of the barn. Even though the gilts exposed to a boar for 30 minutes per day in their own pen had a greater percentage in heat by 270 days of age than the non-exposed gilts, it appears that the added stress of moving had an additive effect on puberty attainment. Kirkwood and Hughes (1982) suggested that "...while the puberty stimulant is boar specific, stress may act synergistically with it to produce the full 'boar effect'." As well, it is possible that the boar's pen contained pheromones built up over time from salivation and urination. These pheromones may have had an additive effect along with the pheromones released from the boar at time of exposure. Kirkwood and Hughes (1980b) reported that moving gilts to a

pen recently vacated by a boar, successfully induces estrus as compared to a control group not moved from their pen of origin.

The advantage of continuous boar exposure over the boar-to-the-gilts or gilts to a group of boars treatments does not appear in the literature. Kirkwood and Hughes (1980a) compared continuous boar exposure to 30 minute daily boar exposure and found no difference in age at puberty for gilts on each treatment. The method of 30 minute exposure is not described in full detail by Kirkwood and Hughes (1980a), therefore it is not known whether the gilts were moved to the boar or vise versa. If the gilts were moved to the boar, the results obtained were similar to those of this study. From other work by the same authors (Kirkwood and Hughes, 1980b) it might be assumed that the gilts were taken to the boar for daily boar exposures. A possible explanation for the advantage of continuous boar exposure over daily exposure of the boar moved to the gilts may lie in the length of exposure to pheromones. In both cases, the gilts did not undergo the stress of being moved from their pens. The difference in treatments lies in the duration of exposure. Although the gilts on continuous exposure did not undergo relocation stress, the fact that they were continually exposed to the triggering pheromones released from the boar and that pheromones were allowed to build up in their pens may have created a similar degree of stimulation to moving and exposing the gilts for 30 minutes per day to a boar in his pen. Boar pheromones constitute the most important part of the boar stimulus in puberty induction of the gilt (Kirkwood

and Hughes, 1980b). It may be that continual exposure to these pheromones has an additive effect over 30 minutes daily exposure in the gilts' pen or increased levels of pheromones due to build up in the pen.

The lower response in puberty attainment of the gilts exposed to a group of boars is difficult to explain. Upon visual monitoring during boar exposure, it appeared that the competitive behavior of the boars resulted in numerous attempts at mounting and profuse salivation by the boars. The stress of this activity coupled with the salivation, which is known to contain triggering pheromones such as 3a-androstenol (Kirkwood et al., 1983), should have been a good stimulus for early puberty induction. This, however, did not occur, resulting in 20.8% fewer gilts in heat by 270 days as opposed to moving the gilts to a single boar on a daily basis. It may be that the activity in the boar group was so high as to result in a loss of receptivity to the boar stimulus by the gilts. The gilts appeared frightened by the boars during exposure and often huddled together in the corner of the pen to avoid boar contact as much as possible. There is no evidence in the literature that this phenomenon has been previously observed, therefore, further study is required to develop a hypothesis.

The loin fat thickness of the gilts at slaughter may indicate an effect of fat level on age at puberty, however, the results are not consistant. The control gilts and the boar to gilts treatment had a significantly ($P < 0.05$) lower loin fat thickness and a lower percentage

of gilts in heat by 270 days of age than the gilts to boar treatment. However, the gilts to group of boars treatment had a lower percentage in heat by 270 days even though they did not have lower fat levels than the gilts to boar or 24 hour exposure treatments.

A recent review by Kirkwood and Aherne (1984) outlines the importance of fat level, along with age and weight, in puberty attainment of the gilt. Since all gilts on this test had normal fat thicknesses for their age and weight, it does not appear that fat thickness was a controlling factor in the differences in age at puberty of the gilts between treatments.

From the results it appears that continuous boar exposure for a 10 day period or 30 minutes daily boar exposure for ten days, moving the gilts to the boar, provide the best stimuli for the early attainment of puberty of gilts as compared to the other boar exposure treatments evaluated. Exposing gilts to a group of boars, although theoretically a good method of exposure, appears not to be satisfactory. The reasons for this require further study.

TABLE 5: EXPERIMENT II: DIET FORMULATION AND COMPOSITION

Ingredients	Percent of Diet
Barley	67.30
Corn	20.00
Soybean Meal (49%)	11.20
Lysine	0.15
Iodized Salt	0.40
Dicalcium Phosphate	0.35
Ground Limestone	0.10
Vitamin - mineral premix[1]	0.50

Composition (Analyzed):

Crude Protein (%)	15.10
Crude Fibre (%)	4.19
Calcium (%)	1.10
Phosphorous (%)	0.98
DE (MJ/kg - calculated)	13.50

---

[1]Supplied the following per kg of diet: 6000 IU Vitamin A; 500 IU Vitamin D; 22 IU Vitamin E; 4.9 mg Riboflavin; 20 mg Pantothenic acid; 29.4 mg Niacin; 44 ug Vitamin B_{12}; 0.6 mg Folic acid; 0.1 mg Biotin; 1251 mg Choline; 4.5 mg Manganese; 80 mg Zinc; 6 mg Copper; 0.15 mg Selenium; 18.9 mg Iron; 100 mg Ethoxyquin.

TABLE 6: EXPERIMENT II: GROWTH PERFORMANCE TO 100 Kg

	Starting Weight[1] (kg)	Days to 100 kg	Average Daily Gain (kg)	Total Gain (kg)	Total Feed (kg)	Feed/Day (kg)	Feed/Gain
Gilts to boar	67.86	37.67	0.85	30.87	110.38	3.44	3.58
Boar to gilts	70.63	34.08	0.86	27.39	97.84	3.04	3.57
24 hr. exposure	70.70	36.92	0.86	31.38	101.26	3.38	3.23
Gilts to group of boars	71.30	39.85	0.81	29.50	104.16	3.33	3.53
Control	72.42	37.21	0.81	29.28	100.72	3.04	3.44
Mean	70.58	37.13	0.84	29.48	102.87	3.25	3.47
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Standard Error	3.64	2.01	0.06	3.27	5.21	0.21	0.11

[1] Means within columns with the same subscript are not significantly different ($P > 0.05$).

TABLE 7: EXPERIMENT II: CARCASS MEASUREMENTS

	Slaughter Weight[1] (kg)	Dressed Weight (kg)	Fat Thickness (cm)
Gilts to boar	135.6	113.5	3.63 a
Boar to gilts	142.6	117.0	3.18 b
24 hr. exposure	137.1	112.0	3.48 ab
Gilts to group of boars	147.4	121.4	3.38 ab
Control	144.6	119.3	3.15 b
Mean	141.5	116.6	3.36
Significance	N.S.	N.S.	$P < 0.05$
Standard Error	10.32	7.47	0.43

[1] Means within columns with the same subscript are not significantly different ($P > 0.05$)

TABLE 8: EXPERIMENT II: REPRODUCTIVE PERFORMANCE

	Percent in Heat by 270 Days[1]	Age at Puberty[2] (Days)	Weight at Puberty[2] (kg)	Ovulation Rate[3] (CL)
Gilts to boar	68.2[a]	209.9	120.8	12.5
Boar to gilts	47.6[ab]	211.8	131.1	12.8
24 hr. exposure	65.2[a]	195.1	117.6	12.7
Gilts to group of boars	47.6[ab]	211.7	127.3	12.7
Control	29.4[b]	212.2	148.0	13.0
Mean	51.6	208.1	129.0	12.7
Significance	$P < 0.05$	N.S.	N.S.	N.S.
Standard Error	-	3.28	9.54	0.77

[1] Means within columns with the same subscript are not significantly different ($P > 0.05$).

[2] Of those gilts attaining puberty by 270 days of age.

[3] Ovulation rate was estimated from the number of corpora lutea present on the ovaries of those gilts attaining puberty by 270 days of age.

Acknowledgements

The technical assistance of A.E. Foster, S.B. Bird and D.J. Nelson is gratefully acknowledged.

VI. General Discussion

The two experiments presented in this report examined the effects of limit feeding and method of boar exposure on puberty attainment of the gilt. From the results of these experiments, it appears that limit feeding to 85% of ad libitum is detrimental to early puberty attainment in the gilt. The reasons for this effect may be complex, with body fat, chronological age and body weight all playing a role. It is interesting to note that in the feed restriction experiment, age at puberty differed between treatments, but weight at puberty was almost identical. This suggests a strong influence of body weight on age at puberty in gilts.

The results of the boar exposure experiment are less clear with no treatment effect on mean age or weight at puberty. There was, however, a difference in percent of gilts in heat by 270 days of age on each treatment. This difference was only significant between the "gilts to the boar" and "continuous boar with gilts" treatments versus the "no boar exposure" gilts. Despite a lack of significance between "boar to the gilts" and the "gilts to the group of boars" treatments versus the other three treatments, numerical differences are large enough to suggest that some methods of boar exposure are more effective than others. The greater percentage of gilts in heat by 270 days of age for the gilts to boar and 24 hour exposure treatments suggests that concentration of pheromones may have an effect on puberty induction of the gilt. In both these treatments, gilts were not only exposed to a boar, but also the pheromones from the boar's urine and saliva left in

the pen over a period of time. The gilts to group of boars treatment appeared to be very stimulatory to the gilts while observing boar exposure, but it appears that the increased activity of the boars due to competition may have caused the gilts to become unreceptive.

From these two experiments it appears that gilts must be allowed to grow at a rate close to their genetic potential by feeding ad libitum. This will allow the gilts to become physiologically ready for puberty induction. Earlier puberty can then be induced by boar exposure. Boar exposure will be most effective if the boar is left in the pen with the gilts for 24 hours per day for a 10 day period, or by moving the gilts to a boar's pen for 30 minutes per day for 10 days. This will allow maximum exposure to stimulatory pheromones emitted by the boar, thus permitting a greater number of gilts in heat by 270 days of age.

VII. References

Aherne, F.X. 1982. Nutrition and management of gilts and sows. University of Alberta Publication.

Aherne, F.X. and Price, M.A. 1979. Relationship between age at puberty (first ovulation) and body composition at market weight in gilts. EAAP, 30th Annual Meeting, Harrogate. Report P5.11.

Aherne, F.X., Christopherson, R.J., Thompson, J.R. and Hardin, R.T. 1976. Factors affecting the onset of puberty, post-weaning estrus and blood hormone levels of Lacombe gilts. Can. J. Anim. Sci. 56:681-692.

Anderson, L.L. and Melampy, R.M. 1972. Factors affecting ovulation rate in the pig. In Pig Production. D.J.A. Cole (Ed.). Butterworths, London. 329-366.

Anonymous. 1982. The Canadian hog carcass grading/settlement system. Canadian Pork Council, Ottawa.

Barber, R.S., Braude, R., Mitchell, K.G. and Thomas, J. 1980. A note on the housing of intact male and female pigs together in the same pen during the growing period to bacon weight. Anim. Prod. 31:321-322.

Booth, W.D. 1972. The occurrence of testosterone and 5 - dihydrotestosterone in the submaxillary salivary gland of the boar. J. Endrocr. 55:119-125.

Booth, W.D. 1984. A note on the significance of boar salivary pheromones to the male - effect on puberty attainment in gilts. Anim. Prod. 39:149-152.

Bronson, F.H. and Desjardins, C. 1974. Circulating concentrations of FSH, LH, estradiol and progesterone associated with acute, male induced puberty in female mice. Endocrinology. 94:1658-1668.

Brooks, P.H. and Cole, D.J.A. 1969. The effect of boar presence on the age at puberty of gilts. Rep. Sch. Agric., Univ. Nott., pp. 1-77

Brooks, P.H. and Cole, D.J.A. 1970. The effects of the presence of a boar on the attainment of puberty in gilts. J. Reprod. Fert. 23:435-440.

Christenson, R.K. and Ford, J.J. 1979. Puberty and estrus in confinement-reared gilts. J. Anim. Sci. 49: 743-751.

Cole, D.J.A., White, M.R., Hardy, B. and Carr, J.R. 1976. Tissue growth in the pig. Anim. Prod. 22: 341-350.

Cunningham, P.J., Naber, C.H., Zimmerman, D.R. and Peo, Jr., E.R. 1974. Influence of nutritional regime on age at puberty in gilts. J. Anim. Sci. 39: 63-67.

Deligeorgis, S.G., English, P.R., Lodge, G.A. and Foxcroft, G.R. 1982. Reproductive development of gilts during the late prepubertal stage: a comparison of procedures for the evaluation of this parameter and the effects of plan of feeding. British Society of Animal Production. Winter Meeting, Harrogate. Paper No. 50.

Deligeorgis, S.G., English, P.R., Lodge, G.A., Foxcroft, G.R. 1984. Comparison of two methods for evaluating reproductive development in prepubertal gilts. Anim. Prod. 38:283-291.

den Hartog, L.A. and Noordewier, G.J. 1984. The effect of energy intake on age at puberty in gilts. Submitted for publication.

Dickerson, J.W.T., Gresham, G.A. and McCance, R.A. 1964. The effect of undernutrition and rehabilitation on the development of the reproductive organs: pigs. J. Endocrin. 29: 111-118.

Dox, I., Melloni, B.J. and Eisner, G.M. 1979. Melloni's illustrated medical dictionary. Williams and Wilkins Co., Baltimore.

Duncan, D.L. and Lodge, G.A. 1960. Diet in relation to reproduction and the viability of the young. Part III. Pigs. Tech. Commun. Commonw. Bur. Anim. Nutr. No. 21.

Dyck, G.W. 1971. Puberty, post-weaning estrus and estrous cycle length in Yorkshire and Lacombe swine. Can. J. Anim. Sci. 51:135-140.

Dziuk, P.J. and Gehlbach, G.D. 1966. Induction of ovulation and fertilization in the immature gilt. J. Anim. Sci. 25:410-413.

Eastham, P.R., Dyck, G.W., Cole, D.J.A. 1984. Reproduction in the gilt 5. The effect of the presence of the mature male during rearing on puberty attainment. Anim. Prod. 39:277-282.

Ensminger, M.E. 1978. The stockman's handbook. The Interstate Printers and Publishers, Inc., Danville.

Foote, W.C., Waldorf, D.P., Chapman, A.B., Self, H.C., Grummer, R.H. and Casida, L.E. 1956. Age at puberty of gilts produced by different systems of mating. J. Anim. Sci. 15:959-969.

Friend, D.W. 1973. Influence of dietary amino acids on the age at puberty of Yorkshire gilts. J. Anim. Sci. 37: 701-707.

Friend, D.W. 1976. Nutritional effects on age at puberty and plasma amino acid level in Yorkshire gilts and on chemical composition, nucleic acid, fatty acid and hydroxyproline contents of the uterus. J. Anim. Sci. 43: 404-412.

Friend, D.W. 1977. Effect of dietary energy and protein on age and weight at puberty of Yorkshire gilts. J. Anim. Sci. 44: 601-607.

Friend, D.W., Lodge, G.A. and Elliot, J.I. 1981. Effects of energy and dry matter intake on age, body weight and backfat at puberty and on embryo mortality in gilts. J. Anim. Sci. 53: 118-124.

Frisch, R.E. 1974. A method of prediction of age of menarche from height and weight at ages 9 through 13 years. Pediatrics. 53: 384-390.

Frisch, R.E. and Revelle, R. 1970. Height and weight at menarche and a hypothesis of critical body weights and adolescent events. Science. 169: 397-412.

Frisch, R.E. and Revelle, R. 1971. Height and weight at menarche and a hypothesis of menarche. Arch. Dis. Child. 46: 695-710.

Frisch, R.E., Revelle, R. and Cook, S. 1973. Components of the critical weight at menarche and and at initiation of the adolescent spurt: Estimated total water lean body mass and fat. Hum. Biol. 40: 295-310.

Haines, C.E., Warnick, A.C. and Wallace, H.D. 1959. The effect of two levels of energy intake on reproductive phenomena in Duroc Jersey gilts. J. Anim. Sci. 18: 347-354.

Hughes, P.E. and Cole, D.J.A. 1975. Reproduction in the gilt: 1. The influence of age and weight at puberty on ovulation rate and embryo survival in the gilt. Anim. Prod. 21:183-189.

Hughes, P.E. and Cole, D.J.A. 1976. Reproduction in the gilt: 2. The influence of gilt age at boar introduction on the attainment of puberty. Anim. Prod. 23:89-94.

Hughes, P.E. and Varley, M.A. 1980. Reproduction in the pig. pp 1-40. Butterworth and Co. Ltd., Toronto.

Hutchens, L.K., Hintz, R.L. and Johnson, R.K. 1981. Genetic and phenotypic relationships between pubertal and growth characteristics of gilts. J. Anim. Sci. 53: 946-951.

Kirkwood, R.N. and Aherne, F.X. 1984. Fat as an essential tissue in reproduction. In press.

Kirkwood, R.N. and Hughes, P.E. 1979. The influence of age at first boar contact on puberty attainment in the gilt. Anim. Prod. 29:231-238.

Kirkwood, R.N. and Hughes, P.E. 1980a. A note on the influence of 'boar effect' component stimuli on puberty attainment in the gilt. Anim. Prod. 31:209-211.

Kirkwood, R.N. and Hughes, P.E. 1980b. A note on the efficacy of continuous v. limited boar exposure on puberty attainment in the gilt. Anim. Prod. 31:205-207.

Kirkwood, R.N. and Hughes, P.E. 1982. Puberty in the gilt - the role of boar stimulation. Pig News and Info. (3)4:389-394.

Kirkwood, R.N., Hughes, P.E. and Booth, W.D. 1983. The influence of boar-related odours on puberty attainment in gilts. Anim. Prod. 36:131-136.

Mavrogenis, A.P. and Robison, O.W. 1976. Factors affecting puberty in swine. J. Anim. Sci. 42:1251-1255.

Melrose, D.R., Reed, H.C.B. and Patterson, R.L.S. 1971. Androgen steroids associated with boar odour as an aid to the detection of oestrus in pig artificial insemination. Br. Vet. J. 127:497-501.

Monteiro, L.S. and Falconer, D.S. 1966. Compensatory growth and sexual maturity in mice. Anim. Prod. 8:179-192.

O'Bannon, R.H., Wallace, H.D., Warnick, A.C. and Combs, G.E. 1966. Influence of energy intake on reproductive performance of gilts. J. Anim. Sci. 25: 706-710.

O'Grady, J.F., Elsley, F.W.H., MacPherson, R.M. and McDonald, I. 1975. The response of lactating sows and their litters to different dietary energy allowances. Anim. Prod. 20: 257-265.

Paterson, A.M. 1982. The controlled induction of puberty. In Control of Pig Reproduction (ed. D.J.A. Cole and G.R. Foxcroft), pp. 139-159. Butterworth, London.

Paterson, A.M. and Lindsay, D.R. 1980. Induction of puberty in gilts. 1. The effects of rearing conditions on reproductive performance and response to mature boars after early puberty. Anim. Prod. 31:291-298.

Pay, M.G., Davies, T.E. 1973. Growth, food consumption and litter production of female pigs mated at puberty and at low body weights. Anim. Prod. 17: 85-91.

Perry, G.C. 1980. Pig courtship behavior : Pheromonal property of andostene steroids in male submaxillary secretion. Anim. Prod. 31:191-199.

Perry, G.C. 1982. The role of olfaction in the reproductive behavior of pigs. Pig News and Info. (3) 1:11-15.

Rampacek, G.B., Kraeling, R.R., Fonda, E.S. and Barb, C.R. 1984. Comparison of physiological indicators of chronic stress in confined and nonconfined gilts. J. Anim. Sci. 58:401-408.

Reutzel, L.F. and Sumption, L.J. 1968. Genetic and phenotypic relationships involving age at puberty and growth rate of gilts. J. Anim. Sci. 27: 27-30.

Robertson, G.L., Grummer, R.H., Casida, L.E. and Chapman, A.B. 1951. Age at puberty and related phenomena in outbred Chester White and Poland China gilts. J. Anim. Sci. 10: 647-656.

Robison, O.W. 1974. Effects of boar presence and group size on age at puberty in gilts. J. Anim. Sci. 39:224. (Abstr.)

Scheimann, C.A., England, D.C., Kennick, W.H. 1976. Initiating oestrus in prepubertal confinement gilts. J. Anim. Sci. 43:210 (Abstr.).

Sorensen, A.M., Thomas, W.B. and Gossett, J.W. 1961. A further study of the influence of level of energy intake and season on reproductive performance of gilts. J. Anim. Sci. 20: 347-349.

Steel, R.G.D. and Torrie, J.H. 1980. Principles and procedures of statistics. McGraw-Hill, New York.

Thompson, L.H. and Savage, J.S. 1978. Age at puberty and ovulation rate in gilts in confinement as influenced by exposure to a boar. J. Anim. Sci. 47:1141-1144.

Wahlstrom, R.C. and Libal, G.W. 1977. Effect of dietary protein during growth and gestation on development and reproductive performance of gilts. J. Anim. Sci. 45: 94-99.

Warnick, A.C., Wiggins, E.L., Casida, L.E., Grummer, R.H. and Chapman, A.B. 1951. Variation in puberty phenomena in inbred gilts. J. Anim. Sci. 10: 479-493.

Whittemore, C.T., Franklin, M.F. and Pearce, B.S. 1980. Fat changes in breeding sows. Anim. Prod. 31: 183-190.

Zimmerman, D.R., 1976. Effect of transport phenomenon, boar contact. Neb. Swine Rep. 76-219:12-13.

Zimmerman, D.R., Carlson, R. and Lantz, B. 1974. The influence of exposure to the boar and movement on pubertal development in the gilt. J. Anim. Sci. 39:230 (Abstr.).

Zimmerman, D.R., Spies, H.G., Rigor, E.M., Self, H.L. and Casida, L.E. 1960. Effect of restricted feeding, crossbreeding and season of birth on age at puberty in swine. J. Anim. Sci. 19: 687-693.